

REMARKS

Claims 12-13, 26, 28, 79, 111-126, 131-133, 146-148, 150-153 and 155-158 are pending. Reconsideration of the pending claims is respectfully requested.

Claim 79 has been amended. Support for the amendment is in the claims previously considered. No new matter has been added with the amendment. The amendment is intended to merely clarify language used in the claims, and the scope of the claims is intended to be the same after the amendment as it was before the amendment.

Rejections under 35 U.S.C. § 112(1).

The Examiner rejected Claim 79 as non-enabled under Section 112(1).

Claim 79 has been amended to correctly recite that the aqueous solution comprises a 2:1 (v/v) ratio of hydrogen fluoride and one or more organic acids.

Accordingly, it is submitted that the claims fully comply with the requirements of Section 112, and withdrawal of this rejection is respectfully requested.

Rejection of Claims under 35 U.S.C. 103(a) (Bartlett, Yamazaki)

The Examiner rejected Claims 12-13, 26, 28, 111-113, 116-119, 123, 125-126, 131-132, and 146-148, 150-153, 155, and 157-158 under Section 103(a) as obvious over USP 4,508,591 (Bartlett) in view of USP 6,198,133 (Yamazaki). This rejection is respectfully traversed.

In Response to Arguments¹, The Examiner asserts that "Bartlett clearly discloses the use of HF in combination with organic complexing agents such as organic acid" — citing to col. 2, lines 53-65 and col. 3, lines 35-55.

The Examiner further asserts² that — although Bartlett discloses the use of an NH₄F: citric acid solution — "*Bartlett discloses the same chemical components (i.e., HF and organic acid) with the instant invention*" (emphasis added) The Examiner thus maintains that "there is no need to substitute Bartlett's etchant formulation with another formulation." The Examiner then states that Yamazaki is used to show that "the dielectric etch rate is a result

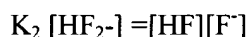
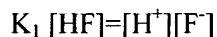
¹ Office Action at page 8 (point 7), 3rd paragraph.

² Office Action at pages 8-9, bridging paragraph.

effective variable" and that it would be "obvious to perform routine experiments to obtain optimal etch rate."

The cited passages in Bartlett³ read as follows (emphasis added):

Etchant baths dissolve SiO₂ in dilute acidic fluoride solutions. Etch rates depend on the concentration HF₂⁻ and HF, but not free fluoride ions. *Ammonium fluoride is typically used as the source of fluoride ions.* In addition, a complexing agent is added which acts as a source of hydrogen ions and as a buffer to stabilize the pH of the solution. The hydrogen ions combine with fluoride ions as described in the following equations *to form HF₂⁻ and HF*:



where K₁ and K₂ are constants depending on temperature and molar concentrations of the fluoride ions. The presence of hydrogen ions therefore controls the etch rate by controlling the concentration of HF₂⁻ and HF.

.....

The present invention discloses the development of a new etchant bath comprising a new organic complexing agent which reduces surface diffusion of the etchant into the resist, thereby resulting in symmetrical lateral etching and uniform patterns. The characteristics of the new complexing agent require that the agent should be an organic acid which is water soluble. The agent must also be available in very high purity and contain extremely low levels of trace metal contamination such as sodium, potassium, and iron which would contaminate the integrated circuit. Several acids which met the above criterion were tested, including: glutaric, tartaric, lactic, ascorbic and citric. Citric acid was selected as the new complexing agent because it met the above criteria and was easily dissolvable in H₂O, while having a very complex molecular structure which limited its ability to undercut or lift the PMMA resist layer 2.

A preferred embodiment of the present invention may be **constructed by mixing 6600 ml of H₂O with 1000 ml 40% aqueous Ammonium Fluoride and 550 gm Citric Acid.** There is no evidence that the concentrations of the Ammonium Fluoride or Citric Acid affect the performance of the present invention with respect to resist lifting. *The concentrations of these chemicals primarily affect the etch rate of the silicon dioxide.* The etchant works effectively with a bath temperature varying from 14 to 20°C. without any noticeable effect on resist lifting.

Contrary to the Examiner's assertion, Bartlett is describing the reaction of *ammonium fluoride* with an organic acid to provide a source of fluoride ions — HF₂⁻ and HF. Bartlett teaches an etch solution composed of ammonium fluoride (as a source of fluoride ions) and organic acid (as a source of hydrogen ions to combine with the fluoride ions of NH₄F) to form HF₂⁻ and HF ions in solution.

Bartlett teaches an etchant solution "constructed by mixing" *ammonium fluoride* and citric acid. Bartlett does not provides any information on the formulation and concentration of

³ Bartlett at col. 2, lines 53-65 and col. 3, lines 35-55.

hydrofluoric acid (HF) and an organic acid to form an etch solution — and particularly not a solution of HF and an organic acid that is combined *at a ratio of 2:1 (v/v)*.

Nor does Bartlett teach the equivalency of a formulated solution of HF and an organic acid with a solution formulated with *ammonium fluoride* and citric acid.

In fact — Bartlett essentially teaches that HF is not an equivalent to NH_4F .

In the Background Section, Bartlett mentions the use of HF as an ingredient in a silicon dioxide etchant — but only *in combination with ammonium fluoride*. In discussing prior art solutions, Bartlett cites to solutions that are formulated with *ammonium fluoride* as the primary ingredient — in combination with either HF or acetic acid (col. 1, lines 27-32, emphasis added):

Silicon dioxide, or glass, is very difficult to etch. *Ammonium fluoride has been the primary ingredient in all silicon dioxide etchants*. In order to increase the pH stability of such etchants, the prior art *has taught the addition of two ingredients, either hydrogen fluoride[sic] or acetic acid*.

Bartlett teaches the use of HF *in combination with NH_4F* — not in combination with an organic acid — and not as an equivalent to NH_4F .

Nowhere does Bartlett teach or suggest a formulated solution of HF combined with an organic acid, particularly a 2:1 solution.

Addressing the Office Action at page 4, 1st paragraph,⁴ the Examiner cites to Bartlett's disclosure at col. 4, lines 1-5, as clearly teaching the use of HF and organic acid, namely, the passage stating "*the concentration of these chemical primarily affect the etch rate of silicon dioxide*." The Examiner thus interprets Bartlett as clearly teaching that the concentration (i.e., the ratio of HF to organic acid[]) and etch rate is result effective variables" which are "commonly determined by routine experiment."

The Examiner has taken the cited passage from Bartlett *out of context* and has made an erroneous interpretation. The cited passage (at col. 4, lines 1-5) — *in context* — is as follows (cols. 3-4, bridging paragraph; emphasis added):

A preferred embodiment of the present invention may be constructed by mixing 6600 ml of H_2O with 1000 ml 40% aqueous *Ammonium Fluoride* and 550 gm *Citric Acid*. There is no evidence that the concentrations of the Ammonium Fluoride or Citric Acid affect the performance of the present invention with respect to resist lifting. The concentrations of these chemical primarily affect the etch rate of the silicon dioxide...

The passage cited by the Examiner specifically refers to the concentration of ammonium fluoride and citric acid — not the concentration of HF and organic acid.

Contrary to the Examiner's assertion, Bartlett does not teach a concentration of HF to organic acid nor that the ratio of HF to organic acid affects the etch rate of silicon dioxide. Rather, Bartlett teaches that the concentration of ammonium fluoride and citric acid affect the etch rate of silicon dioxide.

Furthermore, as discussed above, Bartlett only discusses HF in combination with NH_4F — not in combination with an organic acid, and not as an equivalent of NH_4F .

Additionally, Bartlett teaches the use of the specific etch solution of NH_4F and citric acid to achieve the desired etch rate of silicon dioxide.

The Examiner is again directed to Bartlett at col. 3, lines 35-51 (emphasis added):

The present invention discloses the development of **a new etchant bath comprising a new organic complexing agent** which reduces surface diffusion of the etchant into the resist, thereby resulting in symmetrical lateral etching and uniform patterns. The characteristics of the new complexing agent require that the agent should be an organic acid which is water soluble. The agent must also be available in very high purity and contain extremely low levels of trace metal contamination such as sodium, potassium, and iron which would contaminate the integrated circuit. Several acids which met the above criterion were tested, including: glutaric, tartaric, lactic, ascorbic and citric. Citric acid was selected as the new complexing agent because it met the above criteria and was easily dissolvable in H_2O , while having a very complex molecular structure which limited its ability to undercut or lift the PMMA resist layer 2.

Bartlett's statement that "[t]he concentrations of these chemicals primarily affect the etch rate of the silicon dioxide" refers *specifically* to the concentration of ammonium fluoride and citric acid — not a solution of HF and organic acid as asserted by the Examiner.

As for Yamazaki, in the Office Action at page 3 (4th - 5th paragraphs), the Examiner cited Yamazaki as teaching "a typical removal rate of silicon oxide (low-k dielectric) at 800-1000 Å using acetic acid and inorganic fluorine-comprising compound" and that it would obvious "to modify Bartlett in view of Yamazaki by removing the low-k dielectric layer at a rate greater than 1000 angstroms per minute because the high etching rate will reduce the etching time."

The Examiner has failed to set forth any reasoning as to how Bartlett's solution would actually be modified "in view of Yamazaki."

⁴ See also pages 4-5, bridging paragraph.

In describing the etching rate cited by the Examiner, Yamazaki states as follows (col. 6, lines 38-49; emphasis added):

A base silicon oxide film 602 having a thickness of 2000 Å is formed on a glass substrate by a plasma CVD. A raw material gas in the plasma CVD is monosilane (SiH₄) and dinitrogen monoxide (N₂O). A substrate temperature in film formation is 380 to 500°C., for example, 430°C. The formed silicon oxide film 602 has a relative low etching rate and is solid. This is because since dinitrogen monoxide is used as the raw material gas, a silicon oxide/nitride film containing nitrogen of 1 to 10% is obtained. *A typical etching rate is 800 to 1100 Å/minute using acetic acid-added buffer hydrofluoric acid (ABHF) (hydrofluoric acid: ammonium fluoride: acetic acid=1:50:50) at 23°C.*

Thus, using Yamazaki's disclosure — to achieve a removal rate of 800-1000 Å, Bartlett's solution would necessarily be modified by using acetic acid in the solution — and ammonium fluoride combined with HF.

However, Bartlett explicitly and clearly teaches the use of the specific etch solution of NH₄F and citric acid to achieve the desired etch rate of silicon dioxide, and essentially teaches away from the use of other acids.⁵

Yamazaki provides no useful information to Bartlett's etchant solution or process and there is no basis to combine any of the disclosure of Yamazaki with that of Bartlett. Yamazaki teaches an etchant solution made of NH₄F:HF:acetic acid — not NH₄F:citric acid as taught by Bartlett.

It is further pointed out that the major component of the etchant composition of both Bartlett and Yamazaki is ammonium fluoride — not HF as claimed by Applicant.

Furthermore, the removal rate of 800-1000 Å taught by Yamazaki is achieved by a solution of HF:NH₄F:acetic acid in a ratio of 1:50:50. By comparison, Applicant's invention as claimed is directed to an aqueous solution of HF:organic acid in a ratio of 2:1 to selectively remove a dielectric layer, for example, at a removal rate of the dielectric of greater than about 1000 Å per minute (e.g., Claims 26, 112) and greater than 2000 Å (e.g., Claims 12, 113).

Yamazaki provides no useful information for achieving Applicant's method as claimed.

⁵ See Bartlett at col. 3, lines 35-51 ("Several acids which met the above criterion were tested, including: glutaric, tartaric, lactic, ascorbic and citric. *Citric acid* was selected as the new complexing agent...")

In the Response to Arguments,⁶ the Examiner also cites Yamazaki to show that “the dielectric etch rate is a result effective variable” and that it would be “obvious to perform routine experiments to obtain optimal etch rate.”

However, as pointed out above, Yamazaki teaches a solution of HF:NH₄F:acetic acid in a ratio of 1:50:50 — with ammonium fluoride as the major component. Thus, experimentation based on Yamazaki would necessarily involve varying the ratios of the three ingredients. It would also require *significantly* modifying the ratios of the ingredients to arrive at a 2:1 HF:acid solution as claimed by Applicant. There is no basis in either Yamazaki or Bartlett to make such a modification.

The information in Bartlett and Yamazaki provides no guidance for formulating a 2:1 solution of HF:organic acid.

The Examiner has not combined the cited references based on any teaching or suggestion in any of the references, but rather upon his own analysis.

The Examiner’s subjective statement that it would be obvious to “modify Bartlett in view of Yamazaki by removing the low-k dielectric layer at a rate greater than 1000 angstroms per minute because the high etching rate will reduce the etching time” is merely an unsupported conclusory statement. A conclusory statement that a proposed combination or modification is within the capability of one skilled in the art is not sufficient to support a *prima facie* case of obviousness without some showing of motivation to make the proposed modification. *Ex parte Levengood*, 28 USPQ 2d 1300, 1300 (Bd. Pat. App. & Int’f. 1993).

The Examiner contends that it would be obvious to perform routine experiments based on Yamazaki to obtain an optimal etch rate. However, a removal rate of 800-1000 Å silicon oxide is taught only in the context of a solution of HF:NH₄F:acetic acid in a ratio of 1:50:50 — with ammonium fluoride as the major component. There is no information in Yamazaki that relates to a solution of HF:organic acid — with hydrogen fluoride as the major component — in a ratio of 2:1. Nor is there anything in Yamazaki that teaches or suggests varying the ratio of ingredients.

Thus, there is no clear support in either of the cited references for the Examiner’s argument that Applicant’s process could be achieved by routine experimentation.

⁶ Office Action at page 9, 1st paragraph.

Neither Bartlett nor Yamazaki teach or suggest the use of an HF:organic acid solution to remove dielectric material — particularly a 2:1 (v/v) solution of HF:organic acid which achieves rapid and selective removal of dielectric, particularly at a rate of greater than about 1000 Å/minute.

Accordingly, withdrawal of this rejection is respectfully requested.

Rejection of Claims under 35 U.S.C. 103(a) (Bartlett, Yamazaki, Bell)

The Examiner rejected Claims 114-115, 120-122, 124 and 133 under Section 103(a) as obvious over Bartlett in view of Yamazaki, further in view of USP 6,309,926 (Bell). This rejection is respectfully traversed.

In the Office Action at page 6, 1st paragraph, the Examiner cites Bell for teaching that "*in a wet etching process...that dielectric:photoresist is selectivity greater than 40:1 and one skill in the art can readily tailor a suitable chemistry including concentration to correspond the selectivity*" (emphasis added). The Examiner interprets Bell as teaching that selectivity is a "result effective variable" which can be adjusted by varying the concentration.

In the Response to Arguments,⁷ the Examiner acknowledges that Bell does not disclose a wet chemistry — but uses Bell only to show "that there is motivation (i.e., thin resist layer) for achieving high selectivity between dielectric and photoresist layer." The Examiner maintains that Bartlett implicitly teaches that the selectivity between the dielectric and photoresist is a result effective variable so that it would have been obvious to perform routine experiments to modify Bartlett's etching solution to obtain an optimal etch rate and selectivity between the dielectric and photoresist layers as an expected result.

As Bartlett and Yamazaki are inapplicable for the above-stated reasons, combining the teaching of Bell does not make up for the insufficiencies of the primary references.

Again, the Examiner has not combined the cited references based on any teaching or suggestion in any of the references, but rather upon his own analysis. The Examiner's subjective statement that there is motivation to modify Bartlett's etching solution in view of Bell (and Yamazaki) is again merely an unsupported conclusory statement and without good basis.

⁷ Office Action at page 9, 3rd paragraph.

Bell's statement taken in context is as follows (col. 10, lines 12-36, emphasis added):

Preferably, the nitride layer 80 is etched using an anisotropic etching process--dry or wet etching techniques may be employed, although dry etching is preferred. A nitride:photoresist etch technique may be used to etch the nitride layer 80 to provide the patterned nitride layer 126 and continue to define opening 112 exposing portions of the first gate material layer 78 lying under the patterned nitride layer 110. The nitride:photoresist etch selectivity may be within the range of 2:1 to greater than 40:1, *and one skilled in the art could readily tailor a suitable etch chemistry to correspond to the characteristics of the nitride layer 80 and the patterned photoresist 110. For example, using the patterned photoresist 110 as a mask, the nitride layer 80 may be etched using magnetic enhanced reactive ion etching (MERIE) with CH₃F chemistry* that will not substantially attack the underlying first gate material layer 78. According to the present example, a MERIE method is used with reactant gases of CH₃F (20-100 sccm) and O₂ (50-200 sccm) at a power level within the range of about 500-1000 W, and pressure within the range of about 20-200 mT. This chemistry has very high selectivity to the nitride material over the photoresist material and the selectivity of various embodiments, respectively, *may be tailored* to be greater than 5:1; greater than 10:1; greater than 20:1; greater than 30:1; and greater than 40:1 depending on the particular embodiment employed.

Bell's statement⁸ that "...one skilled in the art could readily tailor a suitable etch chemistry to correspond to the characteristics of the nitride layer and patterned photoresist" relates directly to the particular *dry etch* CH₃F chemistry described by Bell. Bell provides no information on modifying wet chemistry components to vary selectivity.

However, even if, *arguendo*, one were to take notice of Bell's statement — it does not correct the insufficiencies of Bartlett and Yamazaki to arrive at Applicant's process as claimed. As pointed out above, Bartlett teaches an etch solution formed by mixing together NH₄F:citric acid. Yamazaki teaches an etch solution formed by mixing together HF:NH₄F:acetic acid in a ratio of 1:50:50. Both etch solutions are made of ammonium fluoride as the major component.

There is no good basis in either Bartlett, Yamazaki or Bell, to modify (i) the ingredients of Bartlett's NH₄F:citric acid etch solution, or (ii) ratios of ingredients of a wet etch solution, to provide Applicant's method using a 2:1 HF:acid solution to selectively remove a dielectric layer.

The combination of Bell's disclosure with either Bartlett and/or Yamazaki does not teach or suggest Applicant's method as claimed. Accordingly, withdrawal of this rejection is respectfully requested.

⁸ Bell at col. 10, lines 19-23.

Rejection of Claims under 35 U.S.C. 103(a) (Anzaki, Kwag)

The Examiner rejected Claim 79 under Section 103(a) as obvious over USP 6,277,507 (Anzaki) in view of USP 6,232,228 (Kwag).

As noted above, Claim 79 has been amended to recite that the aqueous solution comprises a 2:1 (v/v) ratio of hydrogen fluoride and one or more organic acids. In view of the amendment to Claim 79, insofar as this rejection is maintained, it is respectfully traversed.

As admitted by the Examiner, Anzaki describes a wet etch solution consisting of HF, nitric acid, and water. Kwag discloses a solution of HNO₃, HF, and water.

Neither Anzaki nor Kwag provides any information for an etch solution selective to a dielectric material layer comprising HF and an organic acid.

Accordingly, withdrawal of this rejection is respectfully requested.

Extension of Term. The proceedings herein are for a patent application and the provisions of 37 CFR § 1.136 apply. Applicant believes that no extension of term is required. However, this conditional petition is being made to provide for the possibility that Applicant has inadvertently overlooked the need for a petition for extension of time. If any extension and/or fee are required, please charge Account No. 23-2053.

Based on the above remarks, the Examiner is respectfully requested to reconsider and withdraw the rejections of the claims. It is submitted that the present claims are in condition for allowance, and notification to that effect is respectfully requested.

Respectfully submitted,



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